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The Role of Business Model Innovation in the Relationship of Open Innovation and Innovation Performance in a Dynamic Environment

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Abstract

Business model innovation has gained attention in research and practice, but its antecedents and other outcomes than firm performance remain underresearched. Business model innovation can happen through the introduction of new resources, which open innovation practices could provide, and is an important companion of innovations, which is argued to lift their performance. Hence this study tests a potential mediation of the effect of open innovation on innovation performance through business model innovation and validates a claimed particular effectiveness of open innovation and business model innovation on the success of innovations in technologically turbulent environments using a dataset of 471 firms from the German contribution to the European Community Innovation Survey. This paper finds that business model innovation benefits from the engagement of a firm in open innovation and that the use of business model innovation positively relates to the success of a firm's innovations in both technologically stable and turbulent environments. Business model innovation furthermore facilitates the beneficial effect of open innovation on innovation performance. Finally, technological turbulence does neither moderate the relation of OI nor the one of BMI to innovation performance. The findings offer managers important insights for the success of new products as well as guidance for the effective utilization of open innovation practices.

List of Contents

List of Tables

List of Figures

List of Abbreviations

ACME	Average causal mediation effect
ADE	Average direct effect
BMI	Business model innovation
CIS	Community Innovation Survey
DC	Dynamic capability
DCV	Dynamic capabilities view
EIU	The Economist Intelligence Unit
ICT	Information and communications technology
MIP	Mannheim Innovation Panel
OECD	Organisation for Economic Co-operation and Development
OI	Open innovation
RBV	Resource-based view
SIA	Sequential ignorability assumption
ZEW	Centre for European Economic Research

1 Introduction

Swift & Co. innovated the meat selling business model by shipping packed meat instead of live cattle, which enabled high-scale central slaughter that reduced costs and thereby sparked sales (Teece, 2010, p. 176). This example from the 1870s presents business model innovation (BMI), which would not have been possible without cooperation with refrigerator builders, railway companies or local warehouses in the development and operation of cooled carriages and storages. It shows that cooperation in development exists since early times, but garnered scientific attention only around the 1970s (West et al., 2014, p. 806). ICT is a catalyst for the recent proliferation of this practice, as it fosters knowledge flows between even more distant partners (Gassmann, 2006; Vanhaverbeke, 2006). Chesbrough (2003, 2006b) observed that mobility in expertise and workers contributed to a shift from the closed innovation paradigm dominated by rich corporate giants, which mostly focus on strong internal R&D, to the open innovation (OI) paradigm, which is the development of products and services in a cooperation between a focal firm and customers, suppliers, universities or others.

Equally, though practiced for so long, BMI receives considerable research attention only since 15 years (Foss & Saebi, 2017), which partly stems from many recent examples thereof an evolution of ICT and e-business provided (Amit & Zott, 2001; Casadesus-Masanell & Ricart, 2010). BMI nonetheless gained interest in business and research, which underpins the relevance of studies thereof. In practice, plenty anecdotal evidence points to success from BMI in firms like Dell, Hilti or Rolls Royce (e.g. Johnson et al., 2008; Teece, 2010; Visnjic et al., 2016) and non-scientific surveys capture its importance on manager agendas (EIU, 2005; IBM, 2008) as well as better financial results of BMI-emphasizing firms (IBM, 2006; Lindgardt et al., 2009). Similarly, in research, BMI is widely shown to benefit firm performance in case studies (Sosna et al., 2010; Demil & Lecocq, 2010) as well as in quantitative research (Cucculelli & Bettinelli, 2015; Hartmann et al., 2013; Heij et al., 2014; Zott & Amit, 2007, 2008) and is even posited to lead to competitive advantage (Casadesus-Masanell & Zhu, 2013; Mitchell & Coles, 2003). However, there is still much to learn focusing on constituents of firm performance. For instance, while innovation is a major contributor to firm success (Crépon et al., 1998) and BMI is argued to be an important companion of new technologies (Chesbrough & Rosenbloom, 2002; Teece, 2010), there is scant evidence of the effect of BMI on the more granular level of innovation performance, with solely two studies finding a positive effect but confined to the Austrian and Swedish context (Bengtsson & Tavassoli, 2018; Waldner et al., 2015). Similarly, there is still no clear view about drivers of BMI (Foss & Saebi, 2017; Schneider & Spieth, 2013). Qualitative studies forward that experimentation and trial-and-error learning support BMI through an increase in ideas, knowledge and capabilities (McGrath, 2010; Sosna et al., 2010). However, OI, a source of such resources, is mostly omitted as an antecedent of BMI, thus called for to be researched (Foss & Saebi, 2017). Moreover, since BMI is conceptualized to need an inflow of resources and ideas, and as OI is a source thereof while itself in need of a translator for its input, and as both concepts share a positive impact on innovation performance (Bengtsson & Tavassoli, 2018; Greco et al., 2015; Waldner et al., 2015), there might exist a yet to be researched indirect effect of OI on innovation performance via BMI. Finally, since OI entails an explorative orientation (Dahlander & Gann, 2010; Huizingh, 2011; Randhawa et al., 2016) and BMI involves a certain profoundness in changes (Foss & Saebi, 2017), which are two attributes considered to be necessary and valuable in dynamic environments (Gupta et al., 2006; Teece et al., 1997), both OI and BMI are forwarded as powerful solutions for especially those turbulent settings (Gassmann, 2006; Hamel & Välikangas, 2003; Huizingh, 2011; Saebi, 2015). This advice, however, is largely conceptual, as hardly quantitative studies on contingencies in the innovation-performance relationship exist although research thereof is oft-demanded for both concepts (Foss & Saebi, 2017; Saebi, 2015; West & Bogers, 2014). Strikingly, there is particularly little insight on the environmental dynamism component technological turbulence, although technological developments can simplify or even enable OI (Dahlander & Gann, 2010; Dodgson et al., 2006) and often provide a context for case studies on BMI (Schneider & Spieth, 2013; Wirtz et al., 2016a). Closing this research gap can uncover whether the concepts benefit innovations in technological turbulence and really are more effective in those situations.

Those deliberations lead to the research question *"What is the role of business model innovation in the relation of open innovation and innovation performance?"* and sub-question *"How does technological turbulence influence the relation of open innovation with innovation performance and the relation of business model innovation with innovation performance?"*. In a pursuit to answer these questions, this paper refers to the resource-based view (RBV) (Barney, 1991; Peteraf, 1993) and dynamic capabilities view (DCV) (Eisenhardt & Martin, 2000; Teece et al., 1997) but with the loosened assumptions of the business model concept (Massa et al., 2017). It builds a mediation model based on an argumentation that engagement in OI fosters BMI through its provision of resources and ideas for a recombination thereof, and that BMI benefits the success of innovations by creating a better fit of resources with their context. The moderator technological turbulence is introduced based on arguments about the particular effectiveness of OI and BMI in turbulent environments, as they are posited to counter the uncertainty and short product cycles constituting those settings. The mediation model, which also allows to study relations of OI and BMI to innovation performance, and interactions are tested using a representative sample of 471 firms from the 2013 German Mannheim Innovation Panel (MIP), which provides the German contribution to the European Community Innovation Survey (CIS).

In doing so, this paper forwards theory and managerial practice with several insights. Firstly, the demonstration of an indirect effect of OI on innovation performance via BMI contributes to research by introducing a new mechanism to the OI framework and, in linking OI with BMI, this paper also responds to criticism of OI literature hardly referring to the business model concept (West & Bogers, 2014), although it is part of its theoretical underpinning and a main distinction to past research in this field (West et al., 2014). This finding endows practitioners aiming to elevate their innovative success with another vantage point and expands the yet underdeveloped general management contribution of OI (West et al., 2014).

Secondly, in response to recent calls for the research thereof (Foss & Saebi, 2017), this study provides a strong, while not definite, argument to forward OI as an antecedent that leads to BMI in demonstrating a positive relation of OI to BMI. Together with the validation of a previously found relation between BMI and innovation performance with a third BMI measure in another local context, this thesis contributes to the establishment of a BMI causal web by illustrating antecedents as well as outcomes of BMI. Moreover, it adds to the to date rather marginal body of quantitative BMI studies. By 2016, merely 17 % of BMI papers were quantitative ones, leaving an ample research gap in an area dominated by qualitative studies (Wirtz et al., 2016a, pp. 7-9), which lack generalizability. Furthermore, this paper provides another BMI measure to be used with the multinationally gathered CIS and thereby forwards an important contribution to the academic discourse on a common way to measure BMI and responds to calls to use valuable CIS data with more complex measures (Arundel, 2007). The use of the MIP dataset, which includes many industries and firms of all sizes, also counters gaps in OI and BMI research, which largely omitted SMEs and low-tech industries (Gassmann et al., 2010; Schneider & Spieth, 2013; Van de Vrande et al., 2010).

Thirdly, this study cannot support earlier claims on a conceptual basis that portray OI and BMI as important practices especially in dynamic environments, as it finds a non-significant interaction of OI as well as BMI with technological turbulence. However, BMI is thereby shown to have a positive effect regardless of the technological turbulence, which is of practical relevance since it shows that BMI is positively related to innovation performance also in stable environments and hence offers managers the option to apply BMI on a wider array of situations.

2 Theory and Hypotheses

While papers on OI show little cross-citation to other fields (Randhawa et al., 2016), deliberations on the business model and the innovation thereof are often based on the RBV and DCV (George & Bock, 2011; Schneider & Spieth, 2013), although certain assumptions are loosened (Massa et al., 2017). This section will ground the main concepts of this study in theory and apprehend the difficult task to define those abstract constructs.

2.1 Theoretical Background and Definitions

A recent review has shown that OI is a more studied field than BMI, with 1,700 publications in Scopus compared to 349 (Foss & Saebi, 2017, p. 203). This might explain why, contrary to the BMI field, research has mostly aligned on attributes of OI. Chesbrough and Bogers (2014) refined Chesbrough's (2003, 2006a) initial OI definitions to capture the most important facets of open innovation discussed over years and defined it as "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model" (p. 12).

The attribute "distributed" captures that knowledge is created in dispersed loci of the economy (Chesbrough & Bogers, 2014, p. 9), but can be obtained using forms of cooperation like dyads, networks (Vanhaverbeke, 2006), alliances, platforms (Pisano & Verganti, 2008) or communities (West & Lakhani, 2008). Moreover, it depicts that insights can permeate firm boundaries bidirectionally in a deliberately conducted action, thus OI can refer to an inbound flux of external ideas, knowledge or market-ready products, or to a deliberate outflow of internal developments for external commercialization (Chesbrough, 2003, 2006b), or even to both outbound and inbound flows in a coupled mode (Gassmann & Enkel, 2004). Since this paper focuses on the internal commercialization of innovations, only the inbound facet of OI will be in scope, which is also the most common one (Gassmann et al., 2010). The detail that mechanisms can involve monetary exchange or not captures that exchange processes can be formally agreed, in this case often involve payments, or of informal nature, with less agreement about economic terms and appropriation of gains (Dahlander & Gann, 2010; Elmquist et al., 2009).

The consideration of business models in the commercialization of OI inputs, which Chesbrough (2003, 2006b) demands, discerns OI from common understandings of interfirm development cooperation and hints at the need to leverage this concept in studies of the effect of OI on the commercial performance of its outcomes (West & Bogers, 2014). Strikingly, merely 30 % of OI papers consider this concept, often peripherally (West & Bogers, 2014, p. 823), which might partly owe to the lack of a common definition, and thus heterogeneous view on business models.

The Business Model Concept and its Theoretical Background

Every firm has a business model (Casadesus-Masanell & Ricart, 2010; Chesbrough, 2007a), which makes it an oft-studied topic in research and practice alike (Klang et al., 2014; Massa et al., 2017; Wirtz et al., 2016b). Yet there is no agreement on a definition (Demil et al., 2015; George & Bock, 2011) and also many papers using the concept do not properly define it (Massa et al., 2017; Zott et al., 2011). The divergent definitions might stem from the complexity of the concept and because it has been approached from specific subjects (Massa et al., 2017), like e-business (e.g. Zott & Amit, 2007) or sustainability (e.g. Schaltegger et al., 2012). This kaleido-scope of views yields definitions with divergent numbers of components (Morris et al., 2005) and diverse contents those elements describe: Clauss (2017) found 73 content-wise different elements under 120 names. Given this inconsistency, factors allowing to reach an inclusive but still overseeable definition must be found in a different way. One can be to look at common phenomena business models have been used to explain, which are mainly value creation, per-formance and competitive advantage (Zott et al., 2011, p. 1029). Because the latter two are also a major focus of strategy theories like the RBV or the positioning view (Barney, 1991; Peteraf, 1993; Porter, 1979, 1996), the business model concept is often criticized as being too close to strategy to be a separate field (Markides, 2015; Porter, 2001). However, this concept is argued to go beyond the core strategic topic of value capture (Zott et al., 2011), and explaining how might rebut this criticism while paving the way to a definition.

The RBV is argued to provide a theoretical basis for the business model concept (Amit & Zott, 2011; Schneider & Spieth, 2013). It seeks to explain the heterogeneity of firm results by looking at their different composition of resources, which can be monetary, physical or human assets or knowledge and should be owned or controlled by the firm (Amit & Schoemaker, 1993; Barney, 1991). These resources can lead to a sustained competitive advantage if they are unique, rare, imitable and non-substitutable and if they are used to implement strategies, which cannot be paralleled by existing or future rivals (Barney, 1991; Peteraf, 1993). However, the RBV focuses on value capture only for the focal firm, is criticized to neglect value creation over capture and disregards that value can also be created outside the firm (Adner & Kapoor, 2010; Massa et al., 2017). In turn, business model proponents argue that value is not only captured by shareholders, so the firm itself, but also other stakeholders and that value can be created on the customer-side as well, not only by producers as in the RBV (Massa et al., 2017). Moreover, the RBV struggles to answer how to properly use resources (Priem & Butler, 2001a) and strategy theories often neglect that value needs to be delivered to customers (Massa et al., 2017; Zott et al., 2011). In turn, this issue is central to the business model, as it is forwarded as a mean for better asset utilization leading to improved customer value delivery (Afuah & Tucci, 2001) and is seen as a mediator between inputs and economic outputs (Chesbrough & Rosenbloom, 2002).

This shows that the business model concept deals with value creation and capture as its basis in theory, the RBV, but under relaxed assumptions. As it augments the RBV by also considering value delivery, which concurs with a certain consensus that the business model shall be about value creation, delivery and capture (Desyllas & Sako, 2013), it is justified to follow Teece (2010) in stating that “a business model defines how the enterprise creates and delivers value to customers, and then converts payments received to profits” (p. 173). This definition with three elements is broad enough to serve the diverse industries in this study, but in turn not too open, thus accounting for a criticism of business model definitions being too inclusive (Arend, 2013). Teece's view can be complemented by Zott and Amit's (2010) one of a business model as a "set of activities, as well as the resources and capabilities to perform them—either within the firm, or beyond it through cooperation with partners, suppliers or customers" (p. 217). It reflects the business model concept's theoretical basis in the RBV, as it concurs with it in seeing the firm as a set of resources, but also stresses the loosened assumptions in comparison to it, namely that the locus of value creation and capture as well as resources for it can be external. The business model conceptualization in this section is not only open to the integration of external resources, for instance through OI, but also provides a theoretical basis for the following description of business model innovation, which in essence is the recombination of the resources and capabilities forwarded as constituting a business model (Schneider & Spieth, 2013).

Business Model Innovation

Both the business model concept and RBV are rather static views, which have a reduced explanatory value for fast-changing environments, as a changing context can erode the value of assets and as the resource base determines the possible moves in a path-dependent manner, which can inhibit necessary actions (Demil & Lecoqc, 2010; Eisenhardt & Martin, 2000; Teece et al., 1997). As a reaction, the RBV has been augmented with the view that a firm needs dynamic capabilities, which are capabilities allowing to rearrange the resource base, to build new assets or to strip futile ones in order to attain or maintain competitive advantage in a changing context (Eisenhardt & Martin, 2000; Teece et al., 1997). Since BMI is mostly agreed to be concerned with a reorganization of existing resources or introduction of new ones (Schneider & Spieth, 2013) to increase fit with a setting or re-establish it with an altered one (Teece, 2010), some authors see it as a dynamic capability (Achtenhagen et al., 2013; Mezger, 2014; Saebi, 2015; Zott et al., 2011). Hence, besides from being a useful concept that allows classification based on empirically researched types (Massa et al., 2017) or an analysis of a firm's status quo

(Demil & Lecocq, 2010), the business model can also be an own subject of innovation (Casadesus-Masanell & Zhu, 2013; Massa & Tucci, 2014; Mitchell & Coles, 2003). However, stemming partly from the diverse conceptions of the underlying business model concept, there is also no consensus on a BMI definition (Foss & Saebi, 2017; Schneider & Spieth 2013).

Crucial distinctions in BMI definitions are found in the novelty, profoundness and scope of changes (Foss & Saebi, 2017, 2018; Taran et al., 2015; Wirtz et al., 2016a). In terms of novelty, some authors argue that changes should be new to the firm (e.g. Amit & Zott, 2010; Björkdahl & Holmén, 2013; Bock et al., 2012; Osterwalder et al., 2005; Spieth & Schneider, 2016) while others insist that they shall be at least new to the market or industry (e.g. Johnson et al., 2008; Santos et al., 2009; Snihur & Zott, 2013). Arguments on the profoundness of change are often related to the novelty dimension and revolve around incremental and radical changes, with some authors claiming already the former to constitute BMI (e.g. Amit & Zott, 2012; Bucherer et al., 2012) while others demand radical changes to maintain the character of an innovation (e.g. Comes & Berniker, 2008; Johnson et al., 2008). Finally, there is dissent about the scope of change needed to qualify as BMI. This debate is about the number of changed business model elements, ranging from a single one (e.g. Amit & Zott, 2012; Hartmann et al., 2013), two or more (e.g. Lindgardt et al., 2009), to most or all elements (e.g. Johnson et al., 2008; Yunus et al., 2010). This discord will be the hardest to resolve, since definitions of the underlying business model construct use different terms for the elements of a business model (Fielt, 2012) and often encompass a varying number of elements, mostly four to eight (Morris et al., 2005).

While those diverse conceptualizations will not be reconciled by this paper, they deserve attention in the choice of a working definition. This study will use the one Foss and Saebi (2017) developed after an extensive review of BMI literature, which describes business model innovation as “designed, novel, and non-trivial changes to the key elements of a firm's business model and/or the architecture linking these elements.” (p. 216). BMI should be “designed”, so result from deliberate managerial action (Foss & Saebi, 2017, p. 216), which excludes unintended, random changes. The novelty condition is included to maintain its character as an innovation (Foss & Saebi, 2017, p. 216), but, considering the previous discussion, needs to be further specified. In this study, changes will be novel if they are new to the firm or lead to significant improvements within it, which is the baseline novelty condition for an innovation in the Oslo Manual (OECD, 2005) and also includes incremental change. Moreover, changes must be "non-trivial" to filter out common operational alteration like a horizontal supplier switch (Foss & Saebi, 2017, p. 216). Finally, in terms of scope, this paper requires change in all three key elements of the earlier business model definition, namely value creation, delivery and capture.

2.2 Hypotheses

Several studies have shown positive effects of OI practices on innovation performance throughout diverse industrial as well as regional settings and firm sizes (Berchicci, 2013; Caloghirou et al., 2004; Greco et al., 2015; Sofka & Grimpe, 2010). A positive impact of cooperation on innovation performance has also been presented for a diverse set of partners, like customers (Lau et al., 2010), suppliers (Sofka & Grimpe, 2010) or universities (Faems et al., 2005), but the one of competitors is ambivalent (Greco et al., 2015). The turnover formula price times sales shows levers how OI can spur innovation success proxied as innovation turnover in this paper. OI yields market insights (Bogers & West, 2012), thereby enables firms to craft products more aligned with client needs, which allows higher prices as more benefits are offered (Afuah & Tucci, 2013), or ones built to suit a larger market (Chesbrough, 2003), which can raise sales. Sales can also increase as OI allows firms to develop more products (Gassmann, 2006) through access to R&D knowledge pools beyond ones to be built with own resources (West & Bogers, 2014). Moreover, OI can open access to complementary assets, which foster innovation success by aiding its commercialization (Hagedoorn, 1993; Teece, 1986), and can prevent missing new businesses or complementarities of new technologies with current ones (Chesbrough, 2003), which may happen if firms only focus on present clients and businesses (Enkel et al., 2005).

Nevertheless, profiting from OI is not fully straightforward. Benefits of cooperation are shown to decrease after a certain threshold in the number of cooperation partners due to marginal costs from coordination exceeding the marginal benefits (Laursen & Salter, 2006) or redundancy of knowledge (Burt, 1992). Moreover, while OI is argued to prevent oversight of opportunities (Chesbrough, 2003), overuse thereof can lead to more information than the limited attention of a manager can handle (Bogers et al., 2018). In fact, cooperation can even entail negative effects, for example lead to unintended knowledge spillover (Cassiman & Veugelers, 2002; Enkel et al., 2009) or a disadvantage in value capture if a partner has better complementary assets for the commercialization of a jointly developed innovation (Laursen & Salter, 2014; Teece, 1986). But as these impediments are known and can thus mostly be taken into account by firms planning to cooperate, an overall positive effect of OI on innovation performance is hypothesized:

Hypothesis 1: Open innovation will be positively related to innovation performance.

Reviews on BMI forward OI as an antecedent of BMI and call for studies of this relation (Foss & Saebi, 2017; Massa & Tucci, 2014). Theory can indeed link the two concepts. DCs can be divided into abilities to sense and seize opportunities and ones transforming the resource base (Teece, 2007), with BMI fitting the seize as well as transform category. While OI is rather not a DC since it describes a state of firms, namely engagement in R&D cooperation, it nonetheless entails practices which can constitute the organizational processes that Teece (2018) posits to aid the capability to sense opportunities to be seized by the DC BMI. Firstly, BMI can happen through an influx of new resources or a recombination of current ones (Demil et al., 2015) in a process argued to entail experimentation (McGrath, 2010) or trial-and-error learning (Sosna et al., 2010). OI can supply resources or facilitate access to them and yield ideas (Van de Vrande et al., 2009; West & Bogers, 2014) to recombine existing assets or inspire experiments. Secondly, business models must be crafted with respect to the surrounding setting (Teece, 2010), thus it is argued that leaders must know customer needs and the market for successful BMI

(Demil et al., 2015). It is claimed that environmental scanning is a prerequisite of adaption to the external context (Jennings & Lumpkin, 1992) and that sensed shifts in customer demands spark BMI (Osterwalder, 2004), hence OI can aid BMI, as it is a source for insights about customer needs and market knowledge (Bogers & West, 2012).

Thirdly, OI can clear barriers to BMI, like a dominant logic and inertia or lack of managerial foresight (Chesbrough, 2010; Zott & Amit, 2007). While a clear business model fosters efficient decisions in complex settings by filtering and structuring insights, it can thereby become a dominant logic, which can lead to inertia and omit crucial information deemed irrelevant by the current cognitive structure (Chesbrough, 2010; Chesbrough & Rosenbloom, 2002; Prahalad & Bettis, 1986). The scanning entailed in OI practices helps to assess the importance of inputs (Hagen et al., 2003) and exposes leaders to contradicting views that can lead to reinterpretation of contexts as well as the business model (Berends et al., 2016), which can overturn the dominant logic of successful business models, and sensitizes managers' narrow foresight to opportunities and threats, which are argued to stimulate BMI (Bucherer et al., 2012; Saebi et al., 2017). Moreover, the required openness in the structure, culture and mindset in the adoption of OI (Chesbrough 2006a, 2007b; Gassmann et al., 2010; West & Bogers, 2014) constitutes a beneficial setting for BMI as well (Kaplan, 2012; Santos et al., 2009). Thus, as in the RBV and DCV an alteration of a firm's resource base constitutes BMI and OI offers access to new assets as well as creative ideas to perform this act while also removes barriers to BMI, it is hypothesized:

Hypothesis 2: Open innovation will be positively related to use of business model innovation.

BMI is shown to benefit firm results in diverse industries and locales (Brettel et al., 2012; Cucculelli & Bettinelli, 2015; Hartmann et al., 2013; Heij et al., 2014; Huang et al., 2012; Zott & Amit, 2007). Linking this finding to a significant contribution of innovation performance to firm success (Crépon et al., 1998) allows to think whether the BMI impact on firm results partly stems from a positive influence of it on innovation success. Firstly, in a firm's present market, BMI is argued to uncover new facets of innovations, thereby satisfy unmet needs and provide more benefits (Johnson, 2010; Markides, 2006), which can raise sales or allow higher prices. BMI can also deliver value to omitted customers (Amit & Zott, 2012; Johnson et al., 2008) for whom an offer was too pricey, too complex to handle or if consumers were too distant (Johnson, 2010). Similarly, BMI can help to protrude new markets (Amit & Zott, 2012; Giesen et al., 2007; Johnson, 2010), which just as new clients in present ones can boost innovation sales.

Secondly, business models are conceptually placed between the latent value of technologies, which has to be unveiled with a suitable business model, and the economic output in form of perceived and prescribed value by the client (Chesbrough & Rosenbloom, 2002; Teece, 2010). These business models can, for instance, be innovated to facilitate cheaper access to a product or service (Johnson, 2010; Teece, 2010), which can lead to lower prices and thus spur sales through a more efficient use of resources. BMI can also create links to external sources of value or uncover value through complementarity with other business models (Amit & Zott, 2001; Snihur & Zott, 2014), which can allow a more effective use of resources. Finally, as firms react to customer demand shifts by innovating products, they concurrently must innovate the business model to re-install its fit with the new product to ensure proper value delivery (Teece, 2010).

Third, business model literature is accused of bias towards value creation over capture (Leih et al., 2015; Shafer et al., 2005), but the latter is crucial, as value delivered will not convert by itself to payments (Teece, 2010). BMI can benefit innovations by promoting novel methods to get paid for created value, just as advertiser fees allow Google to offer customers its search for free (Teece, 2010, p. 181). BMI is even argued to bear the potential of superior value creation and capture, hence competitive advantage (Björkdahl, 2009; Chesbrough, 2007a; McGrath, 2010). This advantage could even be a sustained one, as the imitation of a business model can be difficult due to its unique set of assets and partners, which also have to fit firms' culture and strategy (Amit & Zott, 2012; Bucherer et al., 2012). Business model complexity can also create causal ambiguity, an uncertainty around causes for certain outcomes as framed by Lippman and Rummelt (1982), which further repels imitation (Desyllas & Sako, 2013; Foss & Saebi, 2017; Snihur & Zott, 2013). While these thoughts base on the RBV in focusing on a rare, inimitable resource set resulting from BMI, also BMI itself is inimitable, since DCs develop from unique internal routines and learnings of a firm (Teece, 2012). Given these arguments, this paper assumes a positive relation of BMI to innovation success. It follows Waldner et al. (2015), who show a positive relation of firms' BMI level to the share of new product sales using a representative CIS sample of 1,242 Austrian firms, as well as Bengtsson and Tavassoli (2018), who in a longitudinal study of representative CIS samples of Swedish firms find that BMI increases innovation success proxied as new product sales per employee.

Hypothesis 3: The utilization of business model innovation will be positively related to innovation performance.

OI is posited to benefit innovation performance through the R&D knowledge for increased innovation and the market-ready products it provides (Gassmann, 2006; Van de Vrande et al., 2009; West & Bogers, 2014). It is further argued that these new technologies need an adapted business model to prosper (Chesbrough & Rosenbloom, 2002; Teece, 2010). Since OI is also forwarded as a driver of this BMI (Foss & Saebi, 2017), which is demonstrated to have a positive effect on innovation performance (Bengtsson & Tavassoli, 2018; Waldner et al., 2015) just as OI itself does (Greco et al., 2015), it can be supposed that part of the positive effect of OI on innovation performance is routed via BMI which OI practices facilitate. Hence, following suggestions that business models should be used to better understand the effects of OI (Bogers et al., 2016) and that BMI is needed to appropriate the value created by OI practices (Lambert & Davidson, 2013; Randhawa et al., 2016), it is hypothesized:

Hypothesis 4: The positive relationship between open innovation and innovation performance will be mediated by business model innovation.

Examining the Influence of Technological Turbulence

OI and BMI are argued to be very important in fast-changing, uncertain settings (Bogers et al., 2016; de Reuver et al., 2009; Spieth & Schneider, 2016). Environmental dynamism describes frequent and significant changes, which are hard to anticipate, entail uncertainty and happen within various strata of the business context (Dess & Beard, 1984). It is a phenomenon composed of competitive intensity, which is shaped by competitor acts, market turbulence, which refers to fluctuating customer desires, and technological turbulence, which is frequent change in products and their means of production (Jaworski & Kohli, 1993; Kohli & Jaworski, 1990; Miller, 1987). Although all components could moderate the relationship of OI and BMI with innovation performance, particularly technological turbulence will be studied, since this study's context are firms performing product innovation, which often has a strong technological component and can thus be assumed to be affected especially by this dynamism component. Hence this paper will respond to calls to study both OI and BMI with the environment as a contingency (Gassmann, 2006; Schneider & Spieth, 2013) and technological turbulence in particular (Huizingh, 2011; Voelpel et al., 2004), by testing the latter contingency for both concepts.

Turbulent environments entail uncertainty about the direction of technological evolution, and thus about prospectively needed capabilities (Jaworski & Kohli, 1993; Miller, 1987), which impedes decision-making and firm activity. But to some extent, this can be countered by OI and even become a favourable situation. Firstly, OI can allow anticipation of the nature and direction of changes (Vanhaverbeke, 2006), which can prevent oversight or misinterpretation of new business occasions or complementarities with current products created by new technologies (Chesbrough, 2003), which is more likely in such fast-changing contexts. Secondly, this information surplus allows to re-evaluate internal knowledge and capabilities. OI aids the replenishment of resources deemed obsolete in this scan as it enables firms to augment their R&D expertise by quickly learning newly needed skills or at least gives access to them (Ceccagnoli et al., 2010; Laursen & Salter, 2014; Nieto & Santamaria, 2007). Hence, OI can be even more valuable in turbulent settings with high technology turnover, as it facilitates the needed swift creation of new products. Finally, OI requires openness of firms in terms of structure, culture and mindset (Chesbrough 2006a, 2007b; Gassmann et al., 2010; West & Bogers, 2014), which can prove valuable in turbulent environments demanding swift adaption, and can bolster the ability to grasp opportunities by helping to overcome dominant logic and path dependency, which constrain quick action (Prahalad & Bettis, 1986; Teece et al., 1997) and can thus be detrimental in this setting. As OI can provide needed resources in uncertain situations and its exercise stimulates organizational change which is beneficial in those contexts, it is hypothesized:

Hypothesis 5: The positive relation of open innovation to innovation performance is moderated by technological turbulence and is stronger for high technological turbulence.

Though BMI is claimed to be very valuable in dynamic environments, Heij et al. (2014) did not find a significant influence thereof on the BMI to firm performance relation. However, a study at more nuanced levels might still uncover more specific effects. As BMI is often tied to product innovation, the link of BMI and innovation performance is of notable interest, and since innovation commonly entails some connection to technology, particularly the environmental dynamism component technological turbulence can be assumed as impactful in this relation.

DCs are argued to endow a firm with flexibility, which it needs to keep its advantage in dynamic environments by countering threats, seizing opportunities and re-establishing fit with new client needs (Teece, 2018). Firstly, as new technology needs a custom business model (Chesbrough & Rosenbloom, 2002), and many products have to be developed in technological turbulence due to shorter product life cycles (Jaworski & Kohli, 1993; Miller, 1987), the impact of performed or omitted BMI on their commercial success can expected to be amplified. Secondly, business models have to fit their particular environment to succeed (Teece, 2010), but technological turbulence profoundly changes this environment, hence demands BMI to reinstall fit with this altered setting. Thirdly, the technological direction, and thus the context to adapt to, often remains uncertain (Miller, 1987), but as uncertainty affects whole industries in such situations (Dess & Beard, 1984), firms employing BMI might gain an edge through the experimentation and trial-and-error learning this process entails (McGrath, 2010; Sosna et al., 2010). These unique insights can be a resource enabling to find good business models for new technologies and markets quicker than rivals, which can ultimately benefit value delivery to new clients and value appropriation from innovations. Besides its performance outcomes, BMI is argued to entail organizational ones like strategic flexibility, which helps to manoeuvre in complex, dynamic environments (Bock et al., 2012) and might induce the structural agility to seize those arising opportunities. The notion that BMI helps to fend off threats and allows to grasp the opportunities technological turbulence creates leads to the hypothesis:

Hypothesis 6: The positive relation of business model innovation to innovation performance is moderated by technological turbulence and is stronger for high technological turbulence.

Theory and hypotheses are captured in a conceptual model (Figure 1), which provides a blueprint to answer the research questions using the data and methods forwarded in the next chapter.

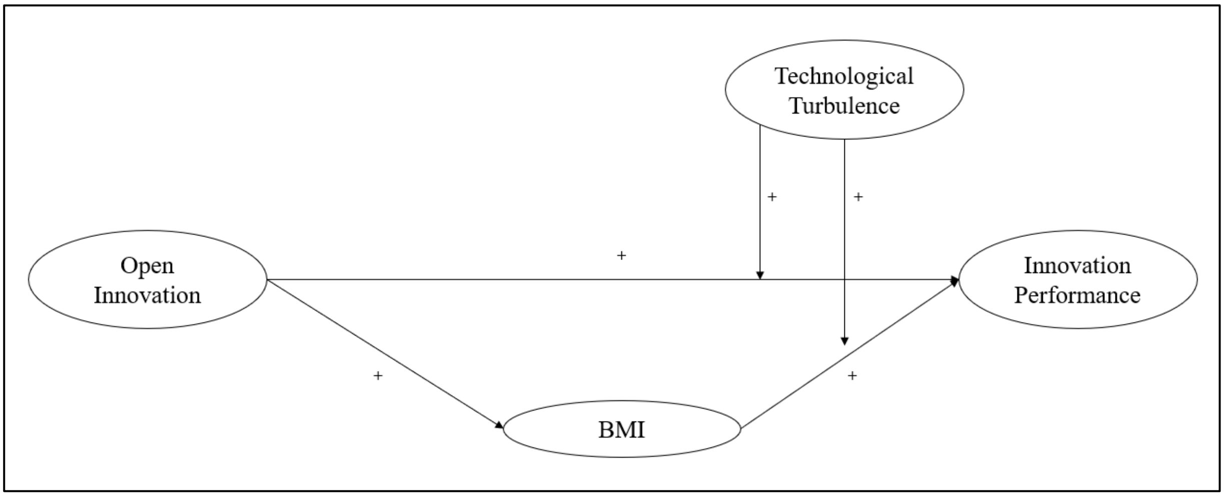

Figure 1 - Conceptual Model

3 Methodology

The aim of this study is to forward understanding of the effect of OI on BMI and innovation performance as well as the underlying mechanisms. Moreover, the contextual factor of technological turbulence in the relations of OI and BMI to innovation performance shall be clarified. This section starts with a description of the dataset as well as sample, defines the measurements and concludes with an outline and discussion of the analytical strategy to test the previously developed hypotheses in the pursuit to answer the research question.

3.1 Data Source and Sample

The data for this paper is derived from the Mannheim Innovation Panel (MIP), which is a stratified random sample representing a population of 276,600 German firms. It is maintained by the Centre for European Economic Research (ZEW) and, since 1993, used for a survey on behalf of the German Federal Ministry for Research and Technology, which covers firms with more than five employees in 21 production and service sectors (Aschhoff et al., 2014). This survey, which follows the Oslo Manual guidelines for the collection of innovation data, is used as the German contribution to the bi-annual European Community Innovation Survey (CIS) (Aschhoff et al., 2014), which contains extensive information about firms' innovation activities as well as related inputs and outputs. The CIS is a widely used data source for innovation studies (Waldner et al., 2015; West et al., 2014) and, to increase reliability, includes definitions as well as examples of variables asked (Sofka & Grimpe, 2010, p. 314). In case of Germany, where a survey is conducted annually, firms participate repeatedly, which further increases familiarity of participants with the surveyed concepts, and extra quality control layers are created, like a comparison to earlier responses of the same firm (Klingebiel & Rammer, 2014, p. 252).

The sample data for this paper is an education-use file of MIP data, which is an absolutely anonymized resample from a scientific-use dataset, which contains factually anonymized MIP data (ZEW, 2018). The sample mimics the distribution parameters of the original micro data (ZEW, 2018) and initially consisted of 2,000 observations, which are drawn from the MIP 2013 that captures firm activities between 2010 and 2012. Only innovating firms which answered every question related to the used variables were included and items with missing values as well as an outlier with an illogically high value for innovation intensity were removed. Many missing values were found in the very specific questions about types of marketing and organizational innovation, hence, to prevent unnecessary exclusion of valid cases, the answers to these questions have been inspected and missing values have been treated as “no” responses if at least one of the questions from each category has been marked with “yes”, assuming that the remaining parts of the question were purposely left blank and implied that this particular type of marketing or organizational innovation is not performed at the firm. As a result, the final sample consists of 471 observations, which is large enough to conduct the aspired research and is representative in the sense that it covers SMEs as well as large firms and contains firm data from a wide variety of production and service industries[1].

3.2 Measurements

Independent Variable

Authors in OI research treat the meaning of openness of innovation ambiguously and one group defines it with regards to the outcome being open, hence usable without restrictions (Dahlander & Gann, 2010). The other group follows Laursen and Salter (2006), who use a stakeholder, input view and see openness on a continuous scale, rising with more cooperating partners. Since OI in this paper is seen from outside-in with a focus on inflows of resources fostered by cooperation with external partners, the stakeholder perspective will be followed. But as the research aim is to pioneer investigation into the relation of cooperation in general and BMI, firm engagement in OI practices will be proxied more broadly using a dichotomous indicator coded 1 if a firm cooperates in R&D with at least one external actor and indicating 0 in case it does not.

1) See Table 9 in Appendix C for further information on the range of industries and distribution of observations over those classes.

Mediator

BMI measurements are available when data is collected from own surveys or firm reports (e.g. Spieth & Schneider, 2016; Velu, 2015; Zott & Amit, 2007), but are only strenuously applicable to secondary data. The same is true for Clauss' (2017) work, which provides a more generally usable measure with three levels of detail under the umbrella of the three business model elements value creation, delivery and capture. This highest level, however, offers a theoretical link to the three considered BMI measurements for CIS data, which employ a similar definition of business model elements and match them to the four innovation types of this survey.

The measure by Waldner et al. (2015) indicates a BMI level by counting yes answers to nine CIS questions determined as being BMI-related by an expert panel. But this construct refers to very specific questions about type and locus of firms' innovations, which leads to a rather low response quality when matched to this study's sample. Particularly the question whether a product is new to the country, market or world and a very specific one about innovation in logistics processes seem to pose an obstacle to respondents. An alternative offering a larger sample size at this data quality are two BMI operationalizations created by capturing initially developed theoretical assumptions with a matched set of existing questions. In doing so, Bengtsson and Tavassoli (2018) and Barjak et al. (2014) measure changes in the business model elements on a more aggregate level, using the filter questions whether a firm performed a type of innovation instead of the ones asking for the specific sub-types thereof as Waldner et al. (2015) do.

Both author teams match the business model elements value creation to product innovation and value delivery to process or organizational innovation, but Bengtsson and Tavassoli (2018) relate only marketing innovation to value capture while Barjak et al. (2014) link marketing and process innovation to it. As noted earlier, BMI can be classified by scope or novelty (Foss & Saebi, 2017, 2018; Hartmann et al., 2013). In terms of scope, both teams see BMI as a concurrent change of each business model element, as, for instance, one solely in value creation would in these operationalizations constitute ‘only’ a normal product innovation. However, Bengtsson and Tavassoli (2018) use a very strict condition by requiring change in all four innovation types, which limits their measure to capture rather radical innovation than the whole scope of BMI. Barjak et al. (2014) are softer on scope, as, given the different matching of business model parts to innovation types, they identify concurrent changes to every business model element when firms simultaneously innovate products with processes or perform product innovation with at least one organizational and marketing innovation, an assumption this paper will parallel.

In terms of novelty, discussions converge towards the condition that to qualify as BMI, business model changes have to be “novel” and “non-trivial” (Foss & Saebi, 2017). However, the “new-to-market” condition of Barjak et al. (2014) describes rather profound than non-trivial change. This strict assumption would qualify to measure more radical BMI but deprives the measure of explanatory power. Hence this paper aligns the Barjak et al. (2014) measurement to the noted recent research consensus by loosening its gravity condition from “new-to-market” to “new-to-firm” changes, which corresponds with other BMI studies (e.g. Bock et al., 2012; Hartmann et al., 2013) and the baseline assumption for an innovation in the Oslo Manual (OECD, 2005). Consequently, this paper will measure *BMI* using a dichotomous variable coded 1 in case a firm simultaneously performed, new-to-firm, product innovation and process innovation or product innovation with at least one marketing and one organizational innovation, else it will be 0.

Dependent Variable

Innovation performance is a widely used measure in innovation management literature (e.g. Grimpe & Kaiser, 2010; Laursen & Salter, 2006; Tsai, 2009). It can be indirectly measured through R&D intensity on the input side or a patent count on the output side (Mairesse & Mohnen, 2010). However, a direct measure is argued to be better, since innovation success can neither be seen as stemming only from R&D nor is success thereof guaranteed and, equally, an abundance of patents does neither contribute to value creation nor capture if not utilized

(Kleinknecht et al., 2002). Hence this thesis will use a direct measure of innovation performance and follow earlier papers in strategic management journals utilizing CIS data (e.g. Klingebiel & Rammer, 2014), which measure *innovation performance* by raw sales resulting from significantly improved or new-to-firm products introduced in the past three years. The use of raw sales makes an increase in performance more directly attributable to the innovation itself, while a relative measure of the share of sales innovations contribute to total turnover might also rise or fall based on the performance of established products (Klingebiel & Rammer, 2014, p. 253).

Moderator

Technological turbulence entails a rapid obsolescence of products or services and uncertainty about the direction of technological development (Jaworski & Kohli, 1993; Miller, 1987). The CIS asks firms to assess the prevalence of these two attributes of technological turbulence on a scale from 0 if non-applicable to 3 if fully applicable. A dichotomous indicator for *high technological turbulence* will be built, coded as 1 if the sum of the two responses is higher than or equal to three, else low technological turbulence will be assumed and the variable coded as 0.

Control Variables

R&D spending has been demonstrated to be a major driver of innovation performance (Crépon et al., 1998; Mairesse & Mohnen, 2002), hence is widely used as an independent or control variable in the form of R&D intensity (e.g. Faems et al., 2005; Laursen & Salter, 2006). However, this measure is criticized to omit investments in worker trainings or the market launch of innovations, all of which are captured under the broader measure of innovation expenditure, which recently often replaces R&D intensity in studies (Mairesse & Mohnen, 2010). This paper will follow this trend and control for R&D and innovation-related spending using *innovation intensity*, measured by innovation expenditures divided by the number of employees.

Number of employees is a common proxy to control for *firm size*, which has been shown to influence innovation performance (e.g. Grimpe & Kaiser, 2010; Laursen & Salter, 2006). Larger firms have more financial and human resources, thus can more readily perform innovation projects, and often possess larger R&D units, leading to economies of scale (Veugelers, 1997). Moreover, a higher resource endowment increases the potential of large firms to acquire or already possess complementary assets necessary for an innovation to prosper (Teece, 1986). Finally, the *industry* dummy variables control for several intersectoral differences, like divergent product life cycle lengths or customer demands, which can impact the number of new products released or their reception and hence their turnover (Leiponen & Helfat, 2010, p. 229).

3.3 Analytical Strategy

The analysis will commence with a univariate analysis to investigate the distribution of variables. Subsequently, a bivariate analysis will be performed to preliminarily study the relation of variables through their correlation and to detect potential multicollinearity.

In the next stage, the relationships will initially be tested using simple linear regression analyses. The assumed mediation in hypothesis 4 will be investigated following the causal steps procedure of Baron and Kenny (1986), which is the most used one to study mediation (MacKinnon et al., 2007) and in the process also allows to test the first three hypotheses. Step 1, as modelled in (1), is pursued to determine whether the causal variable *cooperation* has a significant effect on the outcome *innovation performance*. In step 2, constituted by model (2), it is tested whether the same predictor is significantly related to the mediator *BMI*. Finally, in the last steps, the effect of the mediator and causal variable on the outcome are established, as shown in model (3), which eventually allows to assess whether a mediation takes place by comparing the coefficients of the causal variable *cooperation* from model (1) and (3). *Industry* in all following models represents the 20 industry dummies included as a control.

$$(1)\ \log InnoPerf = b_0 + b_1\ Cooperation + b_2 \log Size + b_3 \log InnoIntensity + b_4\ Industry + \varepsilon$$

$$(2)\ BMI = b_0 + b_1\ Cooperation + b_2 \log Size + b_3 \log InnoIntensity + b_4\ Industry + \varepsilon$$

$$(3)\ \log InnoPerf = b_0 + b_1\ Cooperation + b_2\ BMI + b_3 \log Size + b_4 \log InnoIntensity + b_5\ Industry + \varepsilon$$

The mediator model in (2) contains a dichotomous dependent variable indicating whether BMI took place in a firm or not and the probabilities of those states are investigated using a simple linear regression in a linear probability model. One drawback of this procedure is that the estimated probability can exceed 1, which is illogical. An analysis of the mediator using a logit model can solve this issue, however, is not feasible within the confines of the Baron and Kenny process, which shares a difficulty to include non-linear or non-parametric techniques with other mediation approaches (Imai et al., 2011, p. 772).

A solution can be a non-linear mediation analysis using the methods built into the "mediation" R-package by Imai and colleagues (2010c), who are proponents of a new mediation procedure of causal inference using potential outcomes and counterfactuals (Imai et al., 2011). It allows to perform mediation analyses with various types of statistical models, among them a logit regression, but is based on a strong sequential ignorability assumption (SIA). The SIA as proposed by Imai et al. (2010b) establishes the conditions allowing to infer causality and to identify the average causal mediation effect nonparametrically. It is termed as such as it consists of two consecutive assumptions. The first one, termed no-omitted-variable bias or exogeneity, posits that, accounting for pre-treatment confounders, the treatment condition may not be statistically significantly influenced by the outcome or mediator, hence must be independent thereof (Imai et al., 2011, p. 770). Second, it asserts that, accounting for pre-treatment confounders and the observed treatment status, the mediator is independent of the outcome (Imai et al., 2010a, p. 310). This implies that no unobserved pre-treatment confounders should impact the mediator and outcome relation (Imai et al., 2010b, p. 61). While the assumption cannot be tested, robustness of estimates against breaches of this part of the assumption can be assessed using a sensitivity analysis created by Imai et al. (2010a,b). Moreover, there may not be posttreatment confounders, whether measured or not, influencing the mediator and outcome (Imai et al., 2010b, p. 61). A breach of this assumption cannot be handled using the proposed sensitivity analysis and may require an alternative research design (Imai et al., 2011, p. 787).

Two mediation analyses will be performed following the procedure of Imai et al. (2010c), who fit one model for each the mediator and outcome to eventually calculate the average causal mediation effect (ACME) and average direct effect (ADE). The first analysis will fit the mediator and outcome using the previously presented linear regression models (2) and (3), respectively. In the second approach, the non-linear mediation analysis possible in this procedure will define the mediator using the logit regression in model (4) and fit the outcome using the linear regression in model (3). The first analysis using linear models for both the mediator and outcome is run for two reasons, of which one is to validate the findings of the causal steps approach. Moreover, a sensitivity analysis is needed to analyse how robust the outcomes of the mediation analysis are to the existence of unobserved pre-treatment confounders, which in the noted R-package is not possible for logit models but for linear ones.

$$(4)\ \log\left(\frac{p_{BMI}}{1-p_{BMI}}\right) = b_0 + b_1\ Cooperation + b_2 \log Size + b_3\ log\ InnoIntensity + b_4\ Industry + \varepsilon$$

Finally, hypotheses 5 and 6 will be tested in a simple linear regression analysis. The proposed model for this endeavour augments model (3) by including a dummy variable indicating whether conditions of *high technological turbulence* are perceived by the firm and introduces an interaction term of this variable with *cooperation* as well as *BMI* to test for a moderation:

$$(5)\ \log InnoPerf = b_0 + b_1\ Cooperation + b_2\ BMI + b_3 \log Size + b_4 \log InnoIntensity +$$
$$+ b_5\ Industry + b_6\ Turbulence + b_7\ Koop * Turbulence + b_8\ BMI * Turbulence + \varepsilon$$

4 Results

4.1 Descriptive Statistics

Table 1 presents the descriptive statistics for the considered variables and underpins the representative nature of the sample, which covers firms on a broad range of sizes as well as ones with a diverse range of innovation sales. While neither being an assumption for linear regression models nor logit ones, transformation of variables for a more normal distribution thereof can help to achieve linearity of relations and tackle heteroscedasticity (Pearson, 2010; Starnes et al., 2010). Hence, the highly skewed variables *innovation performance*, *firm size* and *innovation intensity* will be transformed using a natural logarithm. In an effort to obscure the values as little as possible, a small constant of 0.000001 will be added to allow a transformation of zeros in innovation performance and one of 0.00000001 to enable the same for innovation intensity.

Table 1 - Descriptive Statistics

Variable	*N*	*M*	*SD*	Min	Max	Skewness	Kurtosis
Innovation performance	471	3.37	8.37	0	92.48	5.45	39.76
Cooperation	471	0.35	0.48	0	1	0.63	-1.61
BMI	471	0.67	0.47	0	1	-0.70	-1.51
Firm size	471	97.97	145.21	0.30	916.82	2.86	9.36
Innovation intensity	471	0.01	0.02	0	0.27	6.92	73.12
Technological turbulence	471	0.43	0.50	0	1	0.28	-1.93

Notes: The scale of *innovation performance* and *innovation intensity* is million €.

4.2 Bivariate Analysis

Since the variables of interest are not normally distributed, a non-parametric test will be used to detect correlations. Kendall’s tau and Spearman’s rho rank correlation coefficient are two accepted measures to study the strength of relationships without the assumption of normal distribution. In this paper, the latter one will be used and table 2 reports the results of this analysis.

Table 2 - Matrix with Spearman’s Rank Correlation Coefficients

Variable	1	2	3	4	5	VIF
1. Innovation performance						
2. Cooperation	.16** [.06, .25]					1.10
3. Business model innovation	.27** [.19, .36]	.16** [.07, .25]				1.10
4. Firm size	.71** [.65, .76]	.19** [.09, .27]	.15** [.06, .24]			1.08
5. Innovation intensity	.23** [.15, .32]	.22** [.16, .33]	.27** [.19, .36]	.06 [-.05, .15]		1.15
6. Technological turbulence	.00 [-.09, .09]	.02 [-.08, .11]	-.05 [-.14, .03]	-.08 [-.17, .02]	-.02 [-.11, .07]	1.01

Notes: The variables *innovation performance*, *firm size* and *innovation intensity* are logarithmically transformed. Values in brackets indicate the 95 % confidence interval.
* indicates $p < .05$. ** indicates $p < .01$.

Both variables representing the main concepts studied in this paper are significantly correlated ($p < 0.05$) with *innovation performance*, which advocates further investigation. The significant correlation ($p < 0.05$) of *cooperation* and *BMI* warrants to uphold the assumption of a potential mediation and allows to proceed with a test of this hypothesis. The significant correlation ($p < 0.05$) of the control variables *firm size* and *innovation intensity* with *innovation performance* further justifies their inclusion. The high correlation of *firm size* with *innovation performance* at r_s = 0.71 stresses the need to control for it and is logically justified as larger firms can also be expected to have higher absolute sales of new products. The VIF values of variables are below any threshold that would hint at multicollinearity issues and the rather small effect sizes of correlations between the predictor and control variables also meet the logit regression assumption that explanatory variables shall not be too highly correlated.

4.3 Hypothesis Tests

4.3.1 Mediation Analysis Following the Procedure of Baron and Kenny

Table 3 reports the results of the mediation analysis following the Barron and Kenny (1986) procedure. In step 1 of their approach, the regression of *cooperation* on *innovation performance* (path c) is not significant at the 0.05 level with b_c = 0.14. Following the authors, the mediation analysis would already at this point be terminated, as there is no significant effect on the dependent variable to be mediated. However, newer argumentations suggest to proceed (e.g. Rucker et al., 2011; Zhao et al., 2010), for instance if there is sufficient theoretical footing for this relation (Shrout & Bolger, 2002), which can be assumed for the well-studied positive relationship between cooperation and innovation performance (e.g. Greco et al., 2015). Hence model (2) is run to perform step 2, in which the regression of *cooperation* on *BMI* (path a) is significant at the 0.05 level with b_a = 0.10. This allows to proceed to step 3, run through model (3), in which the regression of *cooperation* and *BMI* on *innovation performance* yields b_b = 1.49 significant at the 0.01 level for *BMI* (path b) and $b_{c'}$ = -0.01 for *cooperation* (path c`), which is not significant at the 0.05 level. Given the smaller effect size of *cooperation* in model (3) compared to the one in model (1) a mediation can be assumed. This finding concurs with the joint test of significance, a slight deviation from the causal steps approach proposed by MacKinnon et al. (2002), who assume a mediation if the coefficients b_a and b_b, hence path a and b, are significant.

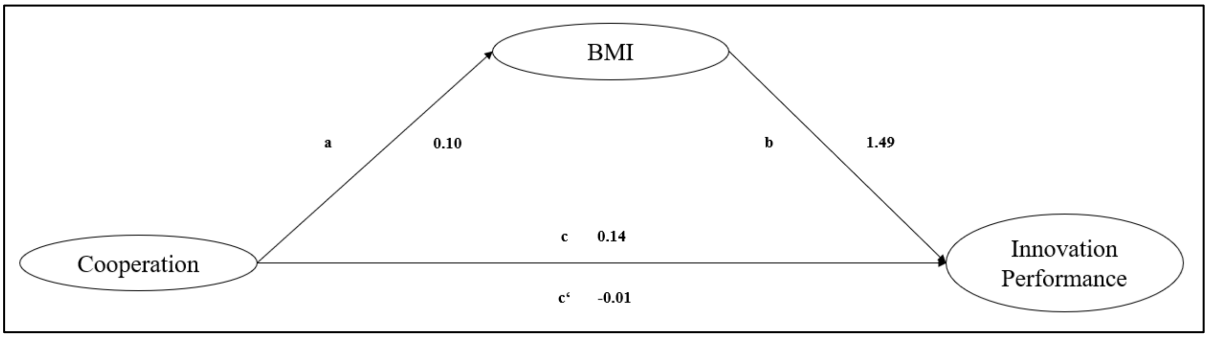

Figure 2 - Path Diagram for the Baron and Kenny Procedure with Results

Table 3 - Models of the Mediation Analysis Following Baron and Kenny (1986)

	Coefficient	95 % Confidence Interval [LL, UL]	
<u>Step 1: Regression of Innovation Performance</u>			
(Intercept)	-3.87**	[-5.16, -2.59]	
Cooperation	0.14	[-0.39, 0.68]	
Firm size	0.85**	[0.67, 1.03]	
Innovation Intensity	0.08**	[0.02, 0.14]	
			R^2 = .374**
			Adj. R^2 = .341**
<u>Step 2: Regression of BMI</u>			
(Intercept)	0.86**	[0.63, 1.08]	
Cooperation	0.10*	[0.01, 0.20]	
Firm size	0.02	[-0.01, 0.05]	
Innovation Intensity	0.02**	[0.01, 0.03]	
			R^2 = .144**
			Adj. R^2 = .100**
<u>Step 3: Regression of Innovation Performance</u>			
(Intercept)	-5.15**	[-6.47, -3.83]	
BMI	1.49**	[0.97, 2.02]	
Cooperation	-0.01	[-0.53, 0.51]	
Firm size	0.82**	[0.64, 1.00]	
Innovation Intensity	0.04	[-0.02, 0.10]	
			R^2 = .415**
			Adj. R^2 = .384**

Notes: Coefficient represents unstandardized regression weights. *LL* and *UL* indicate the lower and upper limits of a 95 % confidence interval, respectively. * indicates p < .05. ** indicates p < .01. All estimates include 20 industry dummies. The variables *firm size* and *innovation intensity* are logarithmically transformed. Results in the models of step 1 and 3 for the logarithmic transformation of the outcome *innovation performance*.

The size of the indirect effect can be estimated with the difference in coefficients approach using the difference between coefficients b_c and $b_{c'}$ (Judd & Kenny, 1981) or with the product of coefficients method using the product of the coefficients b_a and b_b (Sobel, 1982), which in the present case both yield an indirect effect of 0.149. Finally, Baron and Kenny (1986) recommend performing a test following Sobel (1982) to determine whether the demonstrated mediation is significant. Given b_a = 0.10, b_b = 1.49 and their respective standard errors SE_a = 0.047 and SE_b = 0.266, the Sobel test in this case indicates an indirect effect significantly different from zero at the 0.05 level. This is a strong result, given that this test is presumed to have low power (Shrout & Bolger, 2002). However, since the Sobel test assumes normal distribution of the product of coefficients b_a and b_b, which may commonly not hold especially for smaller sample sizes, an assessment of the indirect effect using bootstrapping, which corrects this issue, is recommended in recent years (Zhao et al., 2010). Consequently, this method will be applied to check the robustness of the finding of a significant indirect effect in the subsequent mediation analysis following the procedure of Imai et al. (2010c).

4.3.2 Mediation Analysis Following the Procedure of Imai, Keele and Tingley

Table 5 reports the results of the mediation analysis following the procedure of Imai et al. (2010c). In the approach using a linear mediator model, there is a not significant total effect of *cooperation* on *innovation performance* at the 5 percent level. However, looking at the components constituting the total effect of 0.144, there is an ACME of 0.154 significant at a 0.05 level (p = 0.016) and an ADE of -0.009 not significant at a common significance level. Both findings are in line with the results of the Baron and Kenny procedure, which shows the robustness of the previous estimate. The non-linear mediation analysis employing a logit mediator model yields the result of a total effect of 0.150 and ADE of -0.009, but both not significant at a common significance level. The ACME of 0.159 is significant at the 0.1 level. Using the more conservative result from the linear mediator approach of the mediation procedure following

Imai et al. (2010c) in table 5, it is shown that *cooperation* increases *innovation performance* by 16.7 % through the BMI it contributes to. The results for the logit mediator model in table 4 also show the probability that the firm performed BMI is 6.7 % higher for firms engaged in R&D cooperation, using a calculation of probabilities at means.

Table 4 - Logit Mediator Model of the Non-linear Mediation Analysis

	Coefficient	95 % Confidence Interval [LL, UL]	
Logit regression of BMI (mediator)			
(Intercept)	1.75**	[0.47, 3.05]	
Cooperation	0.55*	[0.06, 1.04]	
Firm size	0.11	[-0.05, 0.27]	
Innovation intensity	0.11**	[0.05, 0.17]	
			McFadden Pseudo R^2 = .117

Notes: Coefficient represents unstandardized regression weights. *LL* and *UL* indicate the lower and upper limits of a 95 % confidence interval, respectively. * indicates p < .05. ** indicates p < .01. Estimate includes 20 industry dummies. The variables *firm size* and *innovation intensity* are logarithmically transformed.

Table 5 - Mediation Analysis Results Following the Procedure of Imai, Keele and Tingley

	Linear Mediator Model	Logit Mediator Model
Average Causal Mediation Effect	0.154*	0.159 .
	[0.039; 0.29]	[0.02; 0.29]
Average Direct Effect	-0.009	-0.009
	[-0.483; 0.40]	[-0.502; 0.44]
Total Effect	0.144	0.150
	[-0.329; 0.56]	[-0.370; 0.60]
N	471	471

Notes: In brackets the lower and upper limits of a 90 % confidence interval, respectively, based on 1,000 bootstrap replications. * indicates p < .05. . indicates p < .1.

Sensitivity Analysis

Imai et al. (2010b, p. 315) posit that if SIA holds and all pre-treatment confounders influencing the mediator and outcome will be observed, the correlation of the error terms of the mediator and outcome model, which they denote as ρ, will be zero. They assert that breaches of the SIA by unobserved confounders will substantiate in a correlation of the errors of the mediator and outcome model and change the ACME estimate. The sensitivity analysis proposed by Imai et al. (2010a,b) recalculates the ACME for different ρ values and thereby allows to assess the robustness of estimates to deviations from the very strong SIA assumption. The plot of the analysis in figure 3 shows the robustness of results for the approach using the linear mediator model against breaches of the SIA. The 90 % confidence interval of the estimated ACME includes zero at a correlation of error terms of 0.2.

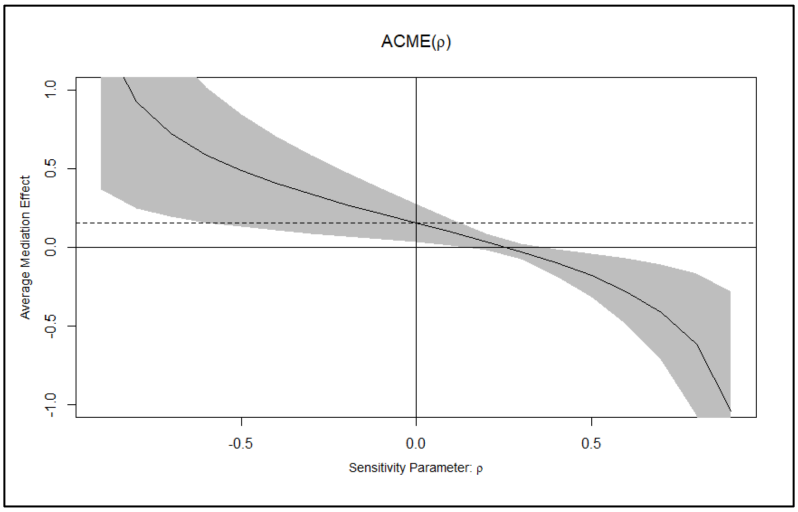

Figure 3 - Sensitivity Analysis

4.3.3 Analysis of the Moderation of Technological Turbulence

Table 6 reports the results of the linear regression analysis, in which the outcome model has been augmented by a dichotomous variable indicating the existence of *high technological turbulence* and interaction terms thereof with *cooperation* and *BMI*. Both the interaction of *high technological turbulence* with *cooperation* and the one with *BMI* are not significant at the 0.05 level. However, also this regression model confirms the previous findings that *BMI* is positively related to *innovation performance,* while *cooperation* remains not significantly related to *innovation performance,* considering a 0.05 significance level for both results.

Table 6 - Analysis of Moderation Effects

	Coefficient	95 % Confidence Interval [LL, UL]
Regression of Innovation Performance		
(Intercept)	-5.15**	[-6.53, -3.76]
Cooperation	-0.37	[-1.05, 0.32]
BMI	1.46**	[0.76, 2.16]
Firm Size	0.82**	[0.64, 0.99]
Innovation Intensity	0.04	[-0.02, 0.10]
High Technological Turbulence	-0.07	[-0.95, 0.81]
Cooperation X High Technological Turbulence	0.86	[-0.16, 1.87]
BMI X High Technological Turburlence	0.24	[-0.80, 1.28]
		R^2 = .423**
		Adj. R^2 = .387**

Notes: Coefficient represents unstandardized regression weights. *LL* and *UL* indicate the lower and upper limits of a 95 % confidence interval, respectively. * indicates p < .05. ** indicates p < .01. . The variables *firm size* and *innovation intensity* are logarithmically transformed. Results for the logarithmic transformation of the outcome *innovation performance*.

4.4 Conclusion

H1 has to be rejected, as neither model provides support for a significant effect of *cooperation* on *innovation performance*. **H2 is supported**, since both the linear model (2) and logit model (4) present a positive effect of *cooperation* on *BMI* significant at the 0.05 level. **H3 is supported**, since *BMI* is shown to have a positive effect on *innovation performance* in both the outcome model (3) and moderation model (5), significant at the 0.01 level for both models. The ACME of the non-linear mediation analysis using the logit regression mediator model is significant at a still common significance level of 0.1, which increases the power of the test but also the propensity of Type I error. But since this finding is backed by an ACME significant at a stricter 0.05 level for the approach using the Imai et al. (2010c) procedure for a linear mediator and outcome model as well as by a significant indirect effect at the 0.05 level using the Baron and Kenny procedure, **H4 is supported**. Finally, there is **neither support for H5 nor H6**, since both interaction effects promoted in this paper are not significant when tested in model (5).

4.5 Limitations

The findings of this study are conditional to certain limitations, which should be considered prior to an inference of theoretical and practical implications thereof in the next chapter. Firstly, the study is limited in implying causality in the presented relationships, as it lacks the time dimension needed to infer causality in common approaches like the one of Baron and Kenny (Wunsch et al., 2010). Moreover, while I am confident to account for the theoretically justified constructs which influence the main concepts of this research, there are certain concepts not covered by the CIS, which might constitute omitted variables biasing the underlying estimate and thus violate the SIA. This would preclude an inference of causality, hence has to be flagged as a limitation and considered as such when interpreting the findings of this study.

Confounders can for instance be found at the top-management team (TMT) level. Decisions on new products or the application of BMI entail a high degree of risk and are made in the top-strata of a firm (Leih et al., 2015; Stieglitz & Foss, 2015), hence those decisions might be influenced by personal attributes of those top-managers like propensity to take risks or by the composition of the TMT, as for instance more gender-diverse TMTs are more risk averse than all-male ones (Baixauli-Soler et al., 2015). TMT impact can also be inferred based on the DCV, which sees a strong influence of TMTs in the cultivation of DCs like BMI is argued to be one (Teece, 2014, 2018). Hence, TMT attributes might pose an unaccounted influence on the mediator as well as outcome and thereby violate the SIA. Moreover, confounding factors could be found on an employee level, with people resisting change out of fear about their (future) position or lack of willingness, which are commonly mentioned barriers for BMI (e.g. Chesbrough, 2010; Sosna et al., 2010) that can also be found in product innovation (Bucherer et al., 2012) and there also hinder the creation as well as success of innovations. Such confounders might also be present on an organization level, for instance in a firm culture generally adverse to change or not ready for it. Consequently, theoretical and managerial implications, which are of special interest in a paper on strategic management, shall be seen with the presented limitations in mind and causal interpretations thereof should be handled cautiously.

Secondly, certain limitations arise from the used operationalizations. While the validation of the BMI and innovation performance relation with another BMI measure is a valuable contribution, it is also a reminder of the crucial issue of a missing common BMI measure. The use of an adapted BMI measurement and general lack of consensus on a coherent construct limit the comparability of results in research (Spieth & Schneider, 2016). Another limitation the used BMI operationalization shares with the close one of Barjak et al. (2014) is that it can yield false positives as it is unknown from the data whether the innovation types at the foundation of this measure are complementary in the sense that they really pertain changes within the same business model or represent innovation within one firm but in different entities. Moreover, owing to the rather limited sample size, the measurement of firms' engagement in OI practices is kept one-dimensional and thus does not capture other attributes which might influence its effect on BMI and innovation success, like the number and characteristics of partners or the depth of cooperation. A measurement at this general level might also incorporate divergent effects, which cancel each other out.

Thirdly, while the original MIP dataset is of very high quality, the anonymisation procedure as developed by Gottschalk (2005) for the education-use data examined in this study slightly hampers data quality. While anonymity can increase the readiness to respond and the honesty of answers, it also limits inclusion of more explanatory variables or controls for confounders measured in other databases. Finally, the many missing answers about the presence of particular types of organizational and marketing innovation indicate that people might not know about it properly, which hints at a general limitation of this data from a survey dependent on the insights of a single respondent.

5 Discussion

The aim of this thesis is to increase knowledge on the relation of OI and BMI and the mechanisms behind their impact on innovation success. Furthermore, understanding of the effect of the contextual factor technological turbulence on the relation of those two concepts with innovation performance should be forwarded. The empirical results suggest that OI is significantly positively related to BMI, which in turn is shown to be significantly positively related to innovation performance. Moreover, a significant, positive effect of OI on innovation performance mediated by BMI is found. This paper cannot support claims that BMI is particularly important in technologically turbulent settings, as results indicate no significant interaction of BMI and high technological turbulence. Contrary to this paper's assumption and to earlier findings, no significant effect of OI on innovation performance is found. This result does not change whether the context is technologically turbulent or stable. This section will outline the theoretical and managerial implications of these results and will propose avenues future research can pursue to eliminate limitations of this study or to deepen understanding of this paper's outcomes.

5.1 Theoretical Implications

While, with the limitations in mind, the study results do not provide definite support to present OI as an antecedent that causes BMI, it can certainly be forwarded that the outcomes provide backing from a quantitative study to claim OI to be an antecedent of BMI, which is stronger than earlier arguments made on a conceptual basis (Foss & Saebi, 2017; Massa & Tucci, 2014). The results illustrate that firms engaged in OI practices seem to constitute a fertile ground for the application of BMI. Defining BMI from the RBV and DCV as a change of the resource base through the influx or development of new resources or reorganization of existing ones, the outcomes of this study allow to state that the access to new resources and ideas for recalibration, which OI practices offer, is positively related to the presence of BMI in a firm. This is a strong contribution as it informs research and practice about beneficial conditions for BMI. Moreover, this paper's findings allow deliberations that engagement in OI can provide firms with crucial information about the surrounding environment and what it might deem valuable, hence can support the successful recombination of the resource base, ergo BMI.

The finding that BMI is positively related to innovation performance lends support to the conceptual argument that innovations with a concurrent BMI perform better (Björkdahl, 2009; Chesbrough & Rosenbloom, 2002; Teece, 2010). While this research is limited in causally inferring that BMI leads to higher innovation performance, it nevertheless presents that innovation performance is significantly higher in the presence of BMI, which contributes a validation of the previously demonstrated positive relationship between BMI and innovation performance (Bengtsson & Tavassoli, 2018; Waldner et al., 2015). Furthermore, this relationship is replicated using a different measure in a different geographical context, which further gives credence to those earlier findings. While this study proposes another way to operationalize BMI, it nevertheless contributes to an alignment of measures through its consensus with earlier papers (Barjak et al., 2014; Bengtsson & Tavassoli, 2018; Clauss, 2017; Waldner et al., 2015) that it shall be developed along the lines of value creation, delivery and capture.

Keeping the limitations concerning a causal interpretation of mechanisms in mind, the demonstration of an indirect effect of OI on innovation performance which is mediated by BMI constitutes a profound contribution to the development of a causal web of BMI as demanded by Foss and Saebi (2017), since it not only gives further support for the determination of antecedents and outcomes, but also, based on quantitative findings, suggests how they could be related through mechanisms involving BMI. Moreover, this paper contributes to OI research by linking the field to other research streams in innovation and strategic management, which have not been covered much yet, as many articles mainly cite other OI literature (Randhawa et al., 2016).

Surprisingly, although BMI is argued to be particularly valuable in dynamic environments (de Reuver et al., 2009; Spieth & Schneider, 2016) like technologically turbulent ones constitute it, this assumed moderation is not backed by this study, which indicates that the effect of BMI on innovation performance is not significantly moderated by technological turbulence. This is in line with a finding that the positive effect of business model renewal, as BMI was termed in the paper of Heij et al. (2014), on firm performance is not significantly moderated by environmental dynamism. Nevertheless, the results shed light on the role of environmental factors in the business model concept, so far a widely neglected aspect compared to the inner workings of business models (Stampfl & Prügl, 2011). The finding that BMI also has a positive effect in stable environments is a strong contribution to research, given that there is little guidance on BMI in rather stable environments since many earlier studies on BMI, and thus their implications, stem from contexts entailing a certain amount of external change (Martins et al., 2015). Based on the RBV and DCV, one can thus argue that BMI fosters a unique recombination of resources which can uncover value in form of effectiveness or efficiency in stable environments, while it helps to realign the resource base to a new context in changing, dynamic ones. Moreover, if the assumption of some researchers that BMI is a DC (Achtenhagen et al., 2013; Mezger, 2014; Saebi, 2015; Zott et al., 2011) is followed, the discussed finding that a positive effect of BMI to innovation performance is present regardless of the technological context backs recent arguments in the DCV that dynamic capabilities can be valuable in both dynamic and stable environments (Zahra et al., 2006) not only dynamic ones (Teece et al., 1997). It further contributes a quantitative study of DCs, which are scarce in a yet rather theoretical research field (Wilden & Gudergen, 2015; Wu, 2010).

This paper tried to replicate earlier findings of a positive effect of OI practices on innovation performance but cannot present an effect that is significant at a statistically considerable level. An explanation for this observation could come from the argument that the full impact of OI might only materialize after a longer time lag (Theyel, 2012). Moreover, there is no indicator in the data whether firms perform OI only since a short time or whether they do so on a continuous basis. Nevertheless, continuous, longer cooperation could strengthen the effect on innovation performance as it might increase trust and thus sharing of information or other assets (Simard & West, 2006). Finally, the effect of cooperation might depend on firms' absorptive capacity, which is the ability to integrate and profit from external inputs (Cohen & Levinthal, 1990) and has been shown to moderate the impact of certain cooperation types on innovation performance, but with different impact directions depending on the collaborator type and radicality of innovation (Tsai, 2009). It is even more surprising, that the effect of OI is also not significant in technologically turbulent environments, although OI is claimed to be particularly important in such settings (Gassmann, 2006; Huizingh, 2011). An explanation might be that the generalization of OI in this research is too broad and thus might incorporate divergent effects, which eventually cancel each other out. Turbulent settings rather necessitate radical innovation, but, for example, collaboration with customers is shown to have a negative impact on radical innovations (Knudsen, 2007), which might offset the beneficial effect of cooperation of the same firm with entities demonstrated to have a positive relation to radical innovation, like universities (Lassen & Laugen, 2017).

5.2 Practical Implications

The RBV is criticized as a theoretical concept, which hardly allows practical inferences to be used by managers (Priem & Butler, 2001a,b). Particularly criticized is the implication of the RBV that, since value is attributed externally, managers do not have much leverage to act upon the attributes of resources they are endowed with (Priem & Butler, 2001b). Consequently, managerial action within the RBV is 'limited' to uncovering and fully utilizing the inherent latent value of resources with their right application. Both Priem and Butler (2001b) in their criticism of the RBV and Barney (2001) in his defence thereof agree that the RBV needs to be enhanced by connections to creative and entrepreneurial practices to guide the use of valuable resources, and the former team forwards the DCV as a theory to suit this purpose. The finding that BMI, which is argued to entail entrepreneurial elements (Schneider & Spieth, 2013; Spieth et al., 2014), is positively related to innovation performance shows leaders that developing the dynamic capability BMI can uncover the value of resources and enhance the utilization of valuable resources as it allows to make resources more appealing to be prescribed value to by tailoring the resource base, and thus the business model, to suit the demands of a focal environment.

The positive effect of OI on BMI and the positive indirect effect of OI on innovation performance mediated by BMI should encourage managers to engage in OI as it can support the above mentioned actions. OI can provide managers with necessary information about the surrounding environment and, since resource value depends on a firm’s market context (Barney, 2001), help them to make a more cognizant assessment of resource value, while it can likewise inform managers about customer needs, hence what else this setting might deem valuable. As far as it can be stated given this paper’s limitations, OI thereby supports the recombination of the resource base which BMI represents, just as it does by facilitating access to valuable resources and creative ideas for a realignment thereof. Hence the concept of business models, innovation thereof and OI can pose an avenue to build the RBV’s missing link between internal resources and the external environment (Priem & Butler, 2001b). Moreover, OI research has much focused on firms’ R&D strata, hence the turn to study OI in relation to business models, an inherently managerial and strategic topic, and the derived practical implications respond to calls to shift the discussion into the manager’s direction (West et al., 2014; Wynarczyk et al., 2013). The finding that the effect of OI on innovation performance is mediated by BMI thus uncovers an important vantage point for managers to foster the effective use of OI outside the realm of R&D. Moreover, leaders can learn from the finding that OI in a firm is positively related to its engagement in BMI that adoption of OI can entail an organizational evolution, which can remove organizational barriers and contribute to the flexibility needed to perform BMI.

Furthermore, BMI is shown to maintain a positive effect on innovation performance throughout different technological backgrounds and the strength of the effect of BMI does not depend on them, hence managers should be apt to address BMI in both technologically stable and turbulent settings. However, this does not mean leaders should approach it regardless of the situation. With the limitation in mind that the BMI measure incorporates different types of BMI and given the conceptual argument that BMI should always be tailored to the surrounding context (Teece, 2010), managers will still face the challenge to find the right level of radicality of changes, thus need to decide whether to start a radically new business model or rather settle for business model adaption with incremental changes, which might for instance be more suitable in a stable market. Finally, the not significant direct effect of the very generally measured impact of OI on innovation performance underpins the need for managers to make deliberate, well-thought choices about cooperation decisions along the lines of the type of cooperation or number and characteristics of partners, as OI practices do not seem to constitute a universal remedy.

5.3 Future Research

Future research could tackle limitations of this study and contribute to a better understanding of the presented outcomes. The limitation of causal interpretability should be approached by a re-evaluation of findings using longitudinal data. The need for a longitudinal study is further underpinned by arguments that both OI and BMI might only show their full impact in the long-term (Foss & Saebi, 2017; Theyel, 2012). Research can also find ways to account for discussed as well as prospectively discovered possible confounders with the potential to lead to breaches of the SIA, which prevent causal interpretation of results. This could be done by using the MIP micro-data, which would allow the matching of information from other databases, or by collecting own data as earlier studies on BMI did (e.g. Heij et al., 2014; Zott & Amit, 2007). Finally, although reverse causality is not presumed in this study, it has to be handled with caution and further investigation into the yet hardly researched antecedents of BMI could validate the assumed unique impact direction from BMI to innovation performance.

Future research can also approach a better understanding of findings of this paper. Although treated as a one-dimensional phenomenon in this study, BMI is multifaceted and differs in scope as well as radicality (Foss & Saebi, 2017), hence different types of BMI might have different effects on innovation performance, which is an avenue of future research of particular importance for instance for managers confronted with the decision which radicality of BMI to choose in a certain context. Likewise, decision-makers will have a particular interest in the sustainability of the positive effect brought on by BMI, which yields another direction for future research using longitudinal data. BMI could provide a more sustainable advantage than other types of innovation, since the access to certain resources or the ability to connect them can be unique to a company (Bucherer et al., 2012; Snihur & Zott, 2013) and the functioning of their workings is often veiled by causal ambiguity, which makes it difficult to imitate (Desyllas & Sako, 2013; Snihur & Zott, 2013). While the definition of openness has been kept quite broad in this paper to study the nature of the relationship between cooperation in general and BMI, future research could narrow down this definition. The effect of OI on the propensity to innovate business models, the resulting type of BMI or the indirect effect on innovation performance could be studied with regards to different characteristics of the actors involved, like customers or suppliers, or in light of breadth and depth of cooperation with other actors, which has been demonstrated to have a varying impact on incremental and radical innovations (Chiang & Hung, 2010). An investigation differentiating among the possible natures of cooperation, so diverse types of networks and agreements, can yield interesting insights as well. Finally, this study could be rerun on standardized CIS data from other countries to probe findings to hold in diverse contexts. For instance, cultures differ along the dimension of uncertainty avoidance (Hofstede, 2001). This can on the supply side impact firms’ propensity to attempt the risky undertaking of BMI and on the demand side influence the performance of innovations accompanied by BMI, which might find less consumer acceptance in cultures rather hesitant to take risks.

6 Conclusion

Research offers plenty advice how the effective use of open innovation can be fostered on a R&D level but remains rather silent on what managers can contribute to the beneficial utilization of OI practices and innovation success potentially resulting from them. Business model innovation is a management responsibility and is forwarded as a conducive companion of new products, some of which can result from OI. This is based on an argumentation that BMI can facilitate a better fit of technologies with their context through a recombination of business model elements and the underlying resources, a realignment which OI can potentially aid with resource access or ideas. But drivers of BMI and contingencies which influence its impact are hardly studied, leaving managers apt to undertake this risky endeavour without many substantiated inferences for the preconditions and consequences of this action. Moreover, both OI and BMI are consulted to managers as particularly effective undertakings in dynamic, technologically turbulent contexts. But since this advice is derived from a theoretical basis, its application in practice still entails a certain amount of risk which can be decisive in such high stakes settings where uninformed decisions can be very impactful, since OI efforts require a dedication of resources, which might miss elsewhere, and as the exercise of BMI is difficult to reverse.

Given these challenges in research and practice, this study investigates a research question about the role of BMI in the relationship of OI to innovation performance and asks a sub-question about the influence of technological turbulence on the relation of OI and BMI to innovation performance. In the pursuit to answer these questions, this paper draws on data from the German contribution to the European Community Innovation Survey and reveals that OI is positively related to the application of BMI in a firm and that BMI positively relates to innovation performance. These results enrich theory with an important contribution to the development of the causal web of BMI in showing, based on a quantitative study, that the potential antecedent OI is positively related to the use of BMI in a firm, and that BMI positively relates to the outcome innovation performance. Based on these results this paper theorizes that the resources and ideas OI provides can benefit the innovation of business models. BMI can further uncover the latent value of technologies and related resources by enhancing their fit to a context, regardless whether this setting is dynamic or stable. Moreover, the demonstrated indirect effect of OI on innovation performance mediated by BMI contributes a finding that transcends the rich knowledge about the workings of OI on the R&D level in uncovering the nature of the role of the managerial stratum of the firm in the effective utilization of OI. Finally, answering the sub-question of this paper, technological turbulence moderates neither the relation of OI to innovation performance, nor the one of BMI to the same outcome. This nonetheless presents a considerable contribution as it informs research that BMI, which is argued to be a dynamic capability, maintains a positive effect also in rather technologically stable environments.

Managers learn from this study that BMI can leverage the performance of their firms' innovations in both stable as well as dynamic contexts and that BMI can facilitate a beneficial effect of OI on the success of new products. Moreover, leaders shall be open to those engagements with other actors, as they constitute a source of resources and ideas for a recombination thereof as well as insights about the market and customers, all of which can support their firms' BMI.

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Appendix A – Questionnaire Items Related to the Relevant Variables

Table 7 - CIS Questions Related to the Relevant Variables

Concept	*Relevant Questions for the Operationalization of this Concept*
Open innovation	9.1. Did your firm perform R&D/innovation-cooperation in the years 2010 to 2012?
Business model innovation	3.1. Did your firm introduce new or significantly improved products/services in the years 2010 to 2012?
	4.1. Did your firm introduce new or significantly improved internal processes (including processes for service delivery or the delivery of products) in the years 2010 to 2012?
	12.1. Did your firm introduce marketing innovations in the following four areas in the years 2010 to 2012? • Introduction of significantly changed designs of products/services (including packaging) • Introduction of new advertising techniques or media in the advertisement of products, introduction of brands • Introduction of new sales channels (including new forms of presentation of products/services) • Introduction of new forms of pricing policy
	12.3. Did your firm introduce organizational innovations in the following three areas in the years 2010 to 2012? • Introduction of new methods for the organization of business processes • Introduction of new forms of work organization • Introduction of new forms in the design of external relations to other firms or institutions
Innovation performance	3.2. How does the turnover of your firm in the year 2012 distribute over the following product types? • In the years 2010 to 2012 introduced new or significantly improved products/services
	1.5. How high was the turnover (including exports) and the exports of your firm in the years 2010 to 2012?

Concept	*Relevant Questions for the Operationalization of this Concept*
Technological turbulence	2.3. Please indicate to what extent the following attributes describe the competitive environment of your firm. • Products/Services are quickly outdated • The technological development is difficult to foresee
Firm size	1.3. How high was the yearly average number of employees of your firm in the years 2010 to 2012?
Innovation intensity	6.2. Please indicate the amount of total expenditures for innovation activities (= expenditures for the activities indicated under A. to H. in question 6.1.) as well as the investments for innovations in your firm for the year 2012.

Note: These questions from the Community Innovation Survey 2013 were translated from German to English by the author of this paper

Appendix B – Operationalization of Concepts

Table 8 - Operationalization of Concepts

Type	*Concept*	*Operationalization*
IV	*Open innovation*	Dichotomous variable coded as 1 if a firm cooperates in R&D with at least one external actor and coded as 0 in case it does not cooperate in R&D with at least one external actor. The variable is labelled "*Cooperation*".
Med	*Business model innovation*	Dichotomous variable coded as 1 if a firm simultaneously performed • new-to-firm product innovation and new-to-firm process innovation OR • new-to-firm product innovation with at least one new-to-firm marketing innovation and at least one new-to-firm organizational innovation Otherwise the variable will be coded as 0 and indicate that no BMI has been performed by the focal firm
DV	*Innovation performance*	Share of turnover from new or significantly improved products multiplied by the turnover of a firm
Mod	*Technological turbulence*	Based on the sum of two survey questions asking for the prevalence of two technological turbulence attributes on a scale from 0 to 3. Technological turbulence increases with this sum, which is on a range of 0 to 6. A dichotomous variable that indicates high technological turbulence is coded as 1 if the sum of the two responses is higher than or equal to 3, else the variable is coded as 0
C	*Firm size*	Number of employees of a firm
C	*Innovation intensity*	Innovation expenditures of a firm divided by the number of its employees
C	*Industry*	For a focal firm, the dummy variable representing the industry the focal firm belongs to is coded as 1, the remaining 19 dummy variables representing industries the focal firm does not belong to are coded as 0

Notes: The variable types are abbreviated as follows: Independent variable = IV, Dependent variable = DV, Mediator = Med, Moderator = Mod, Control variable = C

Appendix C – Descriptive Statistics

Table 9 - Distribution of Observations Across Industries

Industry	*N*	*Percentage*
Chemicals/Pharmaceuticals	29	6.2
Consulting/Advertising	17	3.6
Electronics	60	12.7
Energy/Mining/Oil	12	2.5
Financial Services	12	2.5
Food/Beverages/Tobacco	17	3.6
Furniture/Other Manufacturing	28	5.9
Glass/Ceramics/Concrete	15	3.2
IT-Services/Telecommunications	34	7.2
Machinery/Equipment	33	7.0
Metals	32	6.8
Other Producer Services	13	2.8
Printing/Publishing/Media	28	5.9
Rubber/Plastics	17	3.6
Technical Engineering/R&D	23	4.9
Textiles/Clothing	24	5.1
Transportation/Postal Services	25	5.3
Vehicles	21	4.5
Water Supply/Waste/Recycling	10	2.1
Wholesale Trade	9	1.9
Wood/Paper	12	2.5

Statement of Originality

By signing this statement, I hereby acknowledge the submitted master thesis titled "The Role of Business Model Innovation in the Relationship of Open Innovation and Innovation Performance in a Dynamic Environment" to be produced independently by me, without external help.

Wherever I paraphrase or cite literally, a reference to the original source (journal, book, report, internet, etc.) is given.

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